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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re application of:

TAGUCHI ET AL

Application No.: 09/642,765 Art Unit: 1725

Filed: August 22, 2000 Examiner: C. Cooke

For: LEAD-FREE SOLDER PASTE FOR REFLOW SOLDERING

APPEAL BRIEF

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Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

In support of the Notice of Appeal filed on January 17, 2003 in connection with the present application, the Applicants now submit their Brief.

Real Party In Interest

The real party in interest is Senju Metal Industry Co., Ltd. which is the assignee of record of this application.

Related Appeals and Interferences

There are no appeals or interferences related to this application.

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Status of the Claims

As originally filed, the application contained claims 1 - 12. Claims 13 - 24 were added during prosecution of the application. Claims 1 - 24 are now pending and have been finally rejected. The rejections of all of pending claims 1 - 24 are being appealed. The claims on appeal are found in the Appendix at the end of this brief.

Status of Amendments

No amendments have been filed after the Official Action of October 17, 2002.

Summary of the Invention

This invention relates to a lead-free solder paste useful for joining electronic components to a printed circuit board by reflow soldering.

For many years, solders for use in soldering electronic components to printed circuit boards have been lead-based solders, such as a Sn-Pb eutectic solder containing lead as a major component. Recently, however, there has been a trend in the electronics industry towards the use of lead-free solders due to the adverse effects on the environment of conventional lead-based solders.

One of the difficulties in selecting a composition for a lead-free solder is that many lead-free solders having a melting point that is considerably higher than that of lead-containing solders. Soldering, and particularly reflow soldering with a solder paste, is generally carried out at a temperature which is 40 - 50° higher than the melting point of the solder alloy in the solder paste to optimize spreading of the solder and reduce soldering defects, such as the formation of voids. Given the relatively high melting points of lead-free solders, performing soldering at 40 - 50°C above the melting point of solder frequently brings the soldering temperature into a range which can cause thermal damage to electronic parts being soldered.

The melting point of a lead-free solder can be lowered by the addition of various alloying elements, such as Bi, In, or Zn, but each of these alloying elements causes problems in solder. Bi increases the brittleness of solder, so after soldering, peeling of soldered joints readily occurs if the joints are subjected to an impact. In (indium) reacts with flux in a solder paste and produces degradation of the flux with the passage of time, so the solder paste soon becomes unusable. Zn causes the formation of oxides, which are not only an impediment to solderability but also result in the formation of large voids in soldered portions, so the bonding strength of soldered portions weakens.

The present inventors discovered that soldered joints having excellent mechanical strength, gloss, and impact resistance can be obtained by reflow soldering of a lead-free solder paste formed from a mixture of two or more different types of metal powders having different melting points mixed with a flux, with at least one of the metal powders being a Sn alloy. The overall composition, when melted, of the metal powders in the solder paste is a Sn-Ag-Cu alloy (page 6, line 25 - 28 of the specification).

This solder paste provides a number of advantages. Reflow soldering can be performed with the solder paste at a moderate temperature of 250°C or below or 240°C or below without the formation of voids in soldered portions, thus enabling good quality soldered joints to be formed at a temperature which does not damage electronic components being soldered.

The solder paste according to the present invention also does not cause tombstoning, which is a common problem with conventional Sn-Ag-Cu alloys. Tombstoning is a phenomenon which occurs during reflow soldering of small chip components to a printed circuit board. In tombstoning, a chip component stands up vertically on one of its ends instead of remaining horizontal, so the chip component is not completely electrically connected to the printed circuit board at all of its terminals and cannot function properly.

Yet another advantage of the solder paste according to the present invention is that it

has excellent wettability and printability, which are generally considered to be mutually exclusive properties.

Furthermore, since the solder paste of the present invention does not contain Bi, In, or Zn, it is free of the above-described drawbacks of these alloying elements.

These advantages of the solder paste according to the present invention do not lie merely in the overall composition of the metal powders contained in the solder paste. As shown by Table 1 on page 11 of the present application, a solder paste according to the present invention (any of the Examples in Table 1) has a low incidence of voids, a low incidence of tombstoning, and good printability, whereas a conventional Sn-Ag-Cu solder paste having the same overall composition as a solder paste according to the present invention but containing only a single metal powder (Comparatives Examples 1 and 2) has a high incidence of voids, a high incidence of tombstoning, and poor printability.

Thus, the advantages of the solder paste according to the present invention are derived in part from the use of a plurality of different metal powders. The use of a mixture of different types of metal powders in a solder paste prolongs the time required for the metal powders to completely melt during reflow soldering at a given temperature (page 6, lines 28 - 30). The prolonged melting time prevents the formation of voids in soldered portions, even when the reflow temperature is less than the temperature conventionally required (40 - 50°C above the melting point of the resulting solder alloy) to avoid the formation of voids.

Turning now to the claims, in the invention described by independent claim 1, a lead-free solder paste includes a plurality of different types of metal powder mixed with a flux (page 7, line 9 of the specification of the present application). At least one of the metal powders is a Sn alloy powder (page 7, line 10), and another of the metal powders is selected from a Sn alloy powder, elemental Ag powder, elemental Cu powder, and elemental Sn powder (page 7, line 12). Each Sn alloy powder in the plurality of metal powders includes 0

- 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn (page 7, lines 12 - 13). Furthermore, the plurality of metal powders have a composition when melted of 1 - 5 mass % Ag, at least 0.5 and less than 3 mass % Cu, and a remainder of Sn (page 8, lines 12 - 13 and page 8, lines 19 - 23 for a Cu content of less than 3%).

As described by dependent claim 2, one of the metal powders in the composition of claim 1 may comprise an elemental metal powder of Ag, Cu, or Sn (page 8, line 7).

In the invention described by independent claim 3, a lead-free solder paste includes a plurality of different types of metal powder mixed with a flux (page 7, line 9). The plurality of metal powders include two different Sn alloy powders (page 8, lines 7 - 11). Each Sn alloy powder includes 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn (page 7, lines 12 - 13). In addition, the plurality of metal powders have a composition when melted of 1 - 5 mass % Ag, 0.5 - 3 mass % Cu, and a remainder of Sn (page 8, lines 12 - 13).

As described by dependent claim 4, the two Sn alloy powders in the composition of claim 3 may contain the same components as each other in different proportions (page 8, lines 9 - 10).

As described by dependent claim 5, the plurality of metal powders in the composition of claim 3 may include two different Sn-Ag-Cu alloy powders (page 8, line 9).

In the invention described by dependent claim 6, one of the metal powders in the composition of claim 3 is a Sn-Ag alloy powder and another of the metal powders is a Sn-Cu alloy powder (Example 1-2 in Table 1 illustrates such a paste).

As described by dependent claim 7, the plurality of metal powders in the composition of claim 3 may include a Sn-Ag alloy powder, a Sn-Cu alloy powder, and a Sn-Ag-Cu alloy powder (Example 1-4 in Table 1 illustrates such a paste).

Dependent claim 8 describes a method of soldering a surface mounted device which comprises performing reflow soldering using the solder paste of claim 3 (page 7, lines 16 -

18).

As described by dependent claim 9, the reflow soldering in the method of claim 8 may be performed at a reflow temperature of at most 250°C (page 7, lines 19 - 23).

As described by dependent claim 10, the reflow temperature in the method of claim 9 may be at most 240°C (page 7, lines 19 - 23).

As described by dependent claim 11, the surface mounted device in the method of claim 8 may comprise a chip component (page 9, lines 26 - 30).

As described by dependent claim 12, the method described by claim 8 may include printing the solder paste on a printed circuit board (page 9, lines 21 - 22).

As described by dependent claim 13, the plurality of metal powders in the solder paste described by claim 1 may have a composition when melted containing at most 1.0 mass % of Cu (page 8, lines 22 - 23).

As respectively described by dependent claims 14 and 15, the plurality of metal powders in the solder paste of claim 3 may have a composition when melted containing less than 3.0 mass % or at most 1.0 mass % of Cu (page 8, lines 22 - 23). These two claims respectively describe a broader and a more preferred range for the Cu content.

As described by dependent claim 16, the reflow soldering method of claim 8 may include melting a plurality of metal powders in a solder paste during reflow soldering (page 7, lines 13 - 15).

Dependent claim 17 describes a method of soldering a surface mounted device using the solder paste of claim 1, with the reflow soldering including melting the plurality of powders in the solder paste (page 7, lines 13 - 15). As will be explained below, these claims distinguish the present invention from an invention such as that described in the Paruchuri reference, in which reflow is carried out in a manner such that only one metal powder in a solder paste is melted, with other metal powders intentionally remaining unmelted.

Independent claim 18 describes a method of soldering comprises applying to a

substrate a solder paste including a plurality of different types of metal powder mixed with a flux (page 7, lines 8 - 9). One of the metal powders in the paste is a Sn alloy powder (page 7, line 10), and another of the metal powders is selected from a Sn alloy powder, elemental Ag powder, elemental Cu powder, and elemental Sn powder (page 7, line 12). Each Sn alloy powder includes 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn (page 7, lines 12 - 13). The method further includes heating the solder paste to melt the plurality of metal powders (page 7, lines 13 - 15). The plurality of metal powders have a composition when melted of 1 - 5 mass % Ag, 0.5 - 3 mass % Cu, and a remainder of Sn (page 7, lines 13 - 15).

As described by dependent claims 19, 21, and 23, a soldering method according to the present invention may include completely melting a plurality of metal powders during reflow soldering (page 7, lines 13 - 15 and page 9, line 15).

As described by dependent claims 20, 22, and 24, a reflow soldering method according to the present invention may include completely melting the plurality of metal powders in a single reflow step (page 9, lines 21 - 23). As described below in greater detail, this feature is one of the ways in which the present invention is distinguished from Kazem-Goudarzi, in which a plurality of metal powders must be melted in a plurality of reflow steps, with each reflow step melting only a single metal powder.

Issues

The following issues are presented for review:

Issue 1 - Whether claims 1, 2, and 17 were properly rejected under 35 USC 103(a) as unpatentable over Paruchuri et al (U.S. Patent No. 5,928,404, referred to below as Paruchuri).

Issue 2 - Whether claims 1 - 24 were properly rejected under 35 USC 103(a) as unpatentable over Paruchuri in view of Sakai et al (U.S. Patent No. 6,077,477, referred to below as Sakai).

Issue 3 - Whether claims 1 - 24 were properly rejected under 35 USC 103(a) as unpatentable over Paruchuri in view of Hitch et al (WO 97/09455, referred to below as Hitch).

Issue 4 - Whether claims 3 - 12, 14 - 16, 18 - 20, 23, and 24 were properly rejected under 35 USC 103(a) as unpatentable over Kazem-Goudarzi et al (U.S. Patent No. 5,540,379, referred to below as Kazem-Goudarzi) in view of Seelig et al (U.S. Patent No. 5,352,407, referred to below as Seelig) and further in view of Sakai.

Issue 5 - Whether claims 3 - 12, 14 - 16, 18 - 20, 23, and 24 were properly rejected under 35 USC 103(a) as unpatentable over Kazem-Goudarzi in view of Seelig and further in view of Hitch.

Grouping of the Claims

The claims do not all stand or fall together. Because of the number of claims and the number of issues for review, the grouping of the claims is discussed below separately with respect to each issue.

Argument

The Applicants appeal each of the rejections described above as Issues 1 - 5. Arguments against each of these rejections are presented below.

Issue 1 - The rejection of claims 1, 2, 17, 21 and 22 under 35 USC 103(a) over Paruchuri

For purposes of this rejection only, claims 1 and 2 are considered to stand together, while claims 17, 21, and 22 are patentable separately from claims 1 and 2 and from each other.

This rejection is set forth on page 9 of the Official Action of October 17, 2002. Although the rejection initially states that it applies only to claims 1, 2, and 17, the explanation of the rejection subsequently refers to claims 21 and 22 as well, so it is assumed that the rejection actually applies to all of claims 1, 2, 17, 21, and 22.

This rejection is erroneous for failing to set forth a *prima facie* case of obviousness because there is no motivation for modifying the sole reference in the manner proposed in the Official Action.

The sole reference relied upon in this rejection is Paruchuri. Paruchuri discloses a solder composition having a primary metal powder and an additive metal powder mixed with a flux to form a paste. The primary powder is the same as a powder used in a conventional solder paste. The additive powder is a powder having a melting point substantially higher than the primary powder. Column 3, line 59 - column 4, line 1 of Paruchuri state that "it was discovered that a solder composition having a tin-silver alloy (e.g. 96.5% Sn-3.5% Ag) powder (the primary powder) mixed with additive powder of bismuth (Bi)(3-15% of total metal weight), silver (Ag)(3-11% of total metal weight), copper (Cu)(3-10% of total metal weight) or nickel (Ni)(3-10% of total metal weight), or combinations thereof, provides a solder which has improved fatigue and creep resistance and does not contain toxic ingredients." Thus, the lowest Cu content of the solder composition described by Paruchuri is 3%. In the Examples of Paruchuri, all the pastes containing Cu have a Cu content of at least 5.5 wt %.

The Official Action proposes to modify the Paruchuri reference so as to have a Cu content of less than 3%. The sole reason which the Official Action gives for modifying

Paruchuri is that "the prior art range is so close that one skilled in the art would have expected it to have the same properties". Namely, the Official Action attempts to apply a *per se* rule that any range which is close to a range set forth in a reference is automatically obvious, without there being any need for the reference to have actually suggested the claimed range. In support of this proposition, the Official Action relies on *Titanium Metals Corp. v. Banner*, 227 USPQ 773 (Fed. Cir., 1985).

The above quote by the Examiner is a paraphrase of a statement in *Titanium Metals* concerning the differences between a specific reference and a specific claim: "The proportions are so close that prima facie one skilled in the art would have expected them to have the same properties." *Titanium Metals* at 779. Here, "the proportions" refer to the proportions of a composition disclosed in the reference and the proportions of the claimed composition. However, this statement is not intended as a maxim. Rather, it is no more than an observation, a conclusion of the obviousness of a particular claim in light of a particular reference. In *Titanium Metals*, a reference taught values of the components of an alloy which closely bracketed the values set forth in a claim. Namely, the reference contained graphs showing various compositions for a novel alloy. One composition contained 0.25%Mo-0.75%Ni, and another composition contained 0.31%Mo-0.94%Ni. The claim at issue in that case claimed a composition containing 0.3%Mo-0.8%Ni. The reference did not specify any limits on the values of Mo or Ni, and the values of Mo and Ni in the claim fell between the values for Mo and Ni given in the reference. In light of there being a lack of any teaching in the reference of limits on the values of Mo and Ni (the reference gave only examples of possible values for Mo and Ni), the values of Mo and Ni in the claim could be viewed as no more than an interpolation between the values for those same elements given in the reference. If a reference teaches that a value of 0.25 is satisfactory and that a value of 0.31 is also satisfactory, it is hardly inventive to select a value (such as 0.31) lying between two known acceptable values.

The present situation is quite different from that described in *Titanium Metals*. The Paruchuri reference, unlike the reference relied upon in *Titanium Metals*, sets forth numerical limits, i.e., it defines the Cu content for obtaining improved fatigue and creep resistance as being 3 - 10%. The clear implication is that an alloy with a Cu content outside this range of 3 - 10% does not provide the desired results, i.e., the desired fatigue or creep resistance. A person skilled in the art could not be expected to find any motivation from a reference to modify the reference so as to provide undesirable results.

If a person skilled in the art is to be expected to modify the teachings of a reference, there must be some advantage in his doing so. Otherwise, he has no motivation for the modification. The Official Action has not shown any advantage to modifying the Paruchuri reference so as to use a Cu content outside of the range which Paruchuri teaches, so a motivation for the proposed modification is lacking.

Therefore, as a person skilled in the art would find no motivation to modify the Paruchuri reference as proposed by the Official Action, the proposed modification of the reference is not reasonable, and as such, the rejection based on this proposed modification is unreasonable and does not set forth a *prima facie* case of obviousness. The rejection of claims 1, 2, 17, 21, and 22 is therefore improper.

Claim 17 is patentable for the reasons given above, i.e., for lack of motivation to modify the Paruchuri reference, and it is further patentable in its own right. Claim 17, which depends from claim 1, describes a soldering method comprising performing reflow soldering using the above-described solder paste of claim 1, with the method including melting the plurality of solder powders in the solder paste. Paruchuri does not teach or suggest a method including melting a plurality of solder powders. On the contrary, Paruchuri requires that reflow soldering according to its method <u>not melt</u> a plurality of solder powders.

As discussed above, Paruchuri teaches a solder paste for producing a solder joint with improved fatigue resistance (column 3, line 39). The improved fatigue resistance is achieved by giving a solder joint formed from the solder paste a large stand-off height (column 3, line 38), by which is meant the height of solder between a substrate and a component (column 2, line 12). A large stand-off height is produced by having the solder paste include a primary powder and an additive powder with a higher melting point than the primary powder. The inclusion of the additive powder produces large stand-off heights in the solder joint and thus reduces the magnitude of shear strains in the joint, and it also has a reinforcing effect on the solder joint due to the higher melting point and fine microstructure of the additive powder (column 4, lines 60 - 67). During reflow of the solder paste, the thermal profile is selected such that the primary powder melts (column 5, lines 53 - 57), but such that the additive powder of its solder paste does not melt except for a certain amount of dissolution (column 5, lines 58 - 59). What results is a matrix of the solder formed from the melted primary powder, and unmelted particles of the additive powder embedded in the matrix (column 6, lines 32 - 33). Thus, the additive powder remains in the form of an unmelted powder, without alloying with the primary powder. Paruchuri repeatedly emphasizes that the additive powder does not melt. For example, the first sentence of the Abstract of Paruchuri reads as follows (bold has been added for emphasis):

> A method of manufacturing an electrical solder paste having a primary solder powder and an additive metal powder component **that does not melt during the soldering process**.

The Summary of the Invention in column 3, line 31 of Paruchuri reads as follows:

> The present invention relates to a method of manufacturing an electrical solder paste that includes, in addition to the primary solder powder used in conventional solder paste, an additive metal powder component **that does not melt (except for a certain amount of dissolution) during the soldering process**.

In column 6 of Paruchuri, Example 1 describes a solder paste including a primary

powder of a Sn-Pb-Ag alloy and a powder of bismuth particles. During reflow soldering, the solder paste is passed through a reflow oven and heated to a peak temperature between 210 - 215°C, which is higher than the melting temperature of the primary alloy powder (approximately 179 - 189°C), but well below the melting temperature of the bismuth powder (approximately 271°). According to column 6, line 24, "Therefore, **the bismuth powder did not melt (except for a certain amount of dissolution)** during the reflow process." Column 7, lines 49 - 53 of Paruchuri discuss typical soldering conditions for the solder paste and state that

> The peak soldering temperature will generally be at least 10-15° C. or preferably 10-30° C. above the melting temperature of the primary powder alloy, but below the melting temperature of the additive powder metal.

The claims of Paruchuri also state that only the primary alloy powder is melted during reflow soldering. For example, the last paragraph of claim 1 reads as follows:

> "a flux mixed with ... said solder paste having a melting temperature approximately equal to said first melting temperature and less than said second melting temperature, whereby said solder paste is capable of acting as an electrical interconnect by heating to a temperature above said first melting temperature and below said second melting temperature, **at which temperature said additive powder metal does not melt**..."

Thus, it is clear that not only is there no contemplation in Paruchuri of melting a plurality of metal powders as set forth in claim 17, but that Paruchuri in fact requires that only the primary powder melt and that the secondary additive powder remain <u>unmelted</u> so as to produce a large stand-off height and exert the reinforcing effect discussed in column 2, lines 60 - 67 of Paruchuri.

Accordingly, Paruchuri could not meet all of the claim limitations of claim 17 unless it were modified to use a much higher melting temperature than it actually employs. No motivation for such a modification can be found in Paruchuri itself, which teaches that <u>not melting</u> the secondary additive powder is what provides beneficial effects. The Official Action does not provide any teachings from outside of Paruchuri providing motivation for

such a modification. Page 9 of the Official Action states that the solder paste of Paruchuri may be subjected to reflow "at any temperature sufficient to reflow the solder, including that which would melt the powders". Whether it is physically possible to heat the solder paste of Paruchuri to a temperature such that all the powders would melt is not the issue. The issue is whether a person skilled in the art would be motivated to modify the method of Paruchuri in such a manner. Heating the solder paste of Paruchuri to a temperature which would melt all the powders in the solder paste would defeat the clearly set forth objective of Paruchuri, which is to leave the additive powder unmelted.

If a proposed modification of the prior art would render the prior art invention being modified unsatisfactory for its intended purpose, there is no suggestion or motivation to make the proposed modification. *In re Gordon*, 221 USPQ 1125 (Fed. Cir. 1984). The proposed modification of Paruchuri would render Paruchuri unsatisfactory for its intended purpose, so there is no motivation for the proposed modification. As such, the rejection of claim 17 fails to set forth a *prima facie* case of obviousness so is improper.

Dependent claims 21 and 22 are patentable for the reasons given above with respect to claim 17 and are further patentable in their own right. Claim 21 includes completely melting the plurality of metal powders in the solder paste employed in the method of claim 17, and claim 22 includes completely melting the plurality of metal powder in the solder paste employed in claim 17 in a single reflow step. As discussed above with respect to claim 17, Paruchuri does not disclose melting a plurality of metal powders at all during reflow soldering, so it necessarily does not teach <u>completely</u> melting a plurality of metal powders as set forth in claim 21, or <u>completely</u> melting a plurality of metal powders in a single reflow step as set forth in claim 22. Thus, the cited reference fails to teach all the features of these claims and cannot render them obvious.

Issue 2 - The rejection of claims 1 - 24 under 35 USC 103(a) over Paruchuri in view of Sakai

For the purposes of this rejection only, claims 1 and 2 stand together as a group, and claims 3, 8 - 12, and 14 stand together as a group. These groups of claims are separately patentable from each other, and the remaining claims are separately patentable from these groups of claims and from each other.

This rejection is found beginning at the bottom of page 9 of the Official Action of October 17, 2002. Although page 9 indicates that the rejection applies to claims 1 - 18, pages 10 and 11 also give grounds of rejection for claims 19 - 24, so it is assumed that the rejection actually applies to all of claims 1 - 24.

This rejection is erroneous for failing to set forth a *prima facie* case of obviousness because there is no motivation in the references to combine them in the manner proposed by the Official Action. The rejection is further erroneous in that the references do not teach all of the features of the rejected claims.

The primary reference relied upon in this rejection is Paruchuri, which as described above discloses a lead-free solder paste including a primary solder powder and an additive powder component. Paruchuri states in column 3, line 64 that Cu represents 3 - 10% of the total metal weight of its solder paste, and in the Examples of Paruchuri, all of the pastes have a Cu content of 5.5 wt % or above.

The secondary reference relied upon in this rejection is Sakai, which discloses a lead-free solder for joining electronic parts. According to one embodiment of Sakai, the lead free solder alloy contains 92 - 97% Sn, 3 - 6% Ag, and 0.1 - 2% Cu.

According to pages 10 and 11 of the Official Action, it would have been obvious to have modified the solder paste taught by Paruchuri to employ the composition taught by Sakai with a Cu content of 0.1 - 2% because, according to the Official Action, column 2, lines 28 - 30 of Sakai teach that "a solder joint having this small amount of copper has

enhanced mechanical properties."

The error in this argument in the Official Action is that there are no teachings in the references that modifying Paruchuri in this manner would in any way further, or even meet, the objectives of Paruchuri.

Paruchuri repeatedly states that its object is to increase the fatigue life of a solder joint, particularly in automotive applications. For example, column 3, lines 1 - 4 of Paruchuri state that the invention seeks to enhance solder interconnect fatigue life. To this end, Paruchuri states in column 3, lines 60 - 66 that a solder composition having 3 - 10% of copper as an additive power provides a solder which has improved fatigue and creep resistance.

Sakai teaches a lead-free solder containing a lower Cu content than is employed in Paruchuri, but there is no teaching in Sakai that a lower copper content in any way contributes to fatigue strength, which is the major objective of Paruchuri. Column 2, line 56 of Sakai does say that the addition of silver improves the thermal fatigue resistance characteristics, but Sakai is silent about copper having any advantageous effect on fatigue strength.

There is also no teaching in Sakai that its solder alloy is superior or even comparable in fatigue strength to that of the solder composition of Paruchuri, and so no reason for a person skilled in the art to think that the solder composition of Sakai would be in any way advantageous to the composition of Paruchuri. Sakai states that its alloy has excellent thermal fatigue resistance, but Paruchuri also states that the composition which it employs "leads to increased fatigue life of the solder interconnects" (column 5, lines 5 - 6 of Paruchuri). There is nothing in Sakai that would evidence to a person skilled in the art that Sakai produces better results than does Paruchuri.

Regardless of what adjectives Sakai uses to describe its advantages, there is no evidence that the advantages of a certain chemical composition in Sakai are in any way

applicable to the solder paste of Paruchuri. This is because the solder paste of Paruchuri is intended to function in a totally different manner from the cream solder disclosed in Sakai. As explained with respect to Issue 1, Paruchuri relates to a solder composition having multiple powders in which the primary powder melts while the additive powder does not melt (see lines 1 - 3 of the Abstract of Paruchuri), so a joint formed by the solder composition of Paruchuri is not an alloy of all the metals in the paste used to form the joint. Rather, the joint comprises a matrix formed from the alloy that made up the primary powder, and unmelted particles of the additive powder embedded in the matrix and not alloyed with the primary powder (see, for example, column 6, lines 32 - 33 of Paruchuri). In contrast, Sakai relates to a simple single-powder solder in which all metal components form part of a single alloy. There is no teaching in either reference that a solder joint produced by a multiple-powder composition (like the solder joint of Paruchuri) in which not all the metals are alloyed to each other at the completion of soldering has the same metallurgical characteristics as a solder joint formed from a single alloy powder (like a solder joint formed from the alloy of Sakai). Aside from the lack of teachings, there is no scientific reason to think that a plurality of metals in a joint which are not alloyed to each other will behave in the same way as a single alloy of those same metals. Therefore, even if Sakai did describe its solder paste as having merits not provided by the solder paste of Paruchuri, a person skilled in the art would find no reason in Sakai to modify Paruchuri because the references provide no basis for thinking that the merits of a single-powder paste would be effective in the multiple-powder solder composition of Paruchuri, in which the powders do not end up forming a single alloy, thereby making it fundamentally different in nature from the solder composition of Sakai.

Consider, for example, the examples in Table 1 (column 5) of Paruchuri. In those examples of a solder paste containing Cu, in each case, the primary powder is a Sn-Pb-Ag alloy (Sample 9) or a Sn-Ag alloy (Sample 16), and Cu is the additive powder. Since the

additive powder <u>does not melt</u> (as stated in column 7, lines 52 - 53, for example), what results is <u>not</u> an alloy containing Cu (as in Sakai), but a Sn-Pb-Ag alloy or an Sn-Ag alloy, present together with unmelted Cu particles embedded in a matrix formed from the alloy. Sakai's teachings about the appropriate level of Cu in the specific Cu-containing Sn alloys which it discloses are irrelevant to the solder paste of Paruchuri, in which Cu is never disclosed as being part of an alloy.

The Official Action expects the person skilled in the art to ignore the clear teachings of Paruchuri as to the appropriate Cu content for its unique solder paste and rely on a reference concerning a totally different technology, without there being any evidence that the secondary reference provides results which are even as good of those of the primary reference. As such, the secondary reference provides no motivation to modify the primary reference. Accordingly, the Official Action fails to set forth a *prima facie* case of obviousness with respect to claims 1 - 24.

Claim 3 is patentable for the reasons given above with respect to all of claims 1 - 24, and it further patentably distinguishes the present invention from the cited references because the references fail to teach all the features of this claim. Claim 3 describes a lead-free solder paste including two different Sn alloy powders. Paruchuri does not disclose or suggest such a solder paste.

Column 3, lines 59 - 67 of Paruchuri disclose a solder composition having (a) a Sn-Ag alloy as a primary powder, and (b) elemental bismuth, silver, copper, nickel, "or combinations thereof" as an additive powder. Column 4, lines 7 - 12 disclose a composite solder having (a) a Sn-Pb-Ag alloy as a primary powder, and (b) elemental bismuth, tin, lead, silver, "or combinations thereof" as the additive powder.

The expression "combinations thereof" is widely used in patent applications after a list of items. Often, "combinations thereof" means simply "two or more of the enumerated

items", without any connotation as to what type of combination (other than a combination in the numerical sense) is intended. Other patent applicants assign "or combinations thereof" a specific meaning. Thus, the meaning of "or combinations thereof" is dependent entirely on its context. The Official Action contends that in Paruchuri, the expression refers to alloys of the elements listed before it. However, for the following reasons, it seems clear that in the context of Paruchuri, "combinations" refers to a physical mixture of elemental powders, not to alloys:

(a) Paruchuri uses the term "alloy" numerous times when unambiguously referring to an alloy. There is no instance in which it can be said to use "combinations" to clearly mean alloys. Thus, if Paruchuri had intended to disclose alloys of the listed elements, he would have used the term "alloys".

(b) Paruchuri states in column 4, lines 65 - 67 that the additive powder which it employs has a reinforcing effect on the solder joint due to the higher melting point and fine microstructure. Paruchuri never refers to the alloy powder (the primary powder) as having a fine microstructure, so the implication is that an <u>elemental</u> metal powder has a finer microstructure than an alloy powder. If the additive powder were an alloy, the additive powder would have the same microstructure as the primary powder, and the resulting solder paste would not have a powder with a fine microstructure to provide the desired reinforcing effect.

(c) Every specific example which Paruchuri gives of a solder paste employs an elemental metal powder, not an alloy, as the additive metal powder (see Table 1 of Paruchuri).

(d) The Abstract echoes the language of column 3, lines 59 - column 4, lines 15 (describing specific solder compositions), but with an important difference in wording:

> The additive metal is selected from the metal group comprising Sn, Pb, Ni, Cu, Ag, and Bi **and mixtures thereof**.

The Abstract uses the language "and mixtures thereof" in exactly the same location in a sentence where the description in columns 3 and 4 of the specification uses "or combinations thereof", thus indicating that "and combinations thereof" means "and mixtures thereof", i.e., physical mixtures of elemental metal powders, not to alloys.

Even if the language "or combinations thereof" were interpreted to include alloys, this interpretation would not result in Paruchuri teaching two Sn alloy powders in a lead-free solder paste. The only lead-free solder composition disclosed by Paruchuri is that in column 3, lines 59 - 66, which as set forth above includes (a) a Sn-Ag alloy as the primary powder, and (b) elemental bismuth, silver, copper, nickel "or combinations thereof" as an additive powder. Interpreting "or combinations thereof" to mean "alloys thereof" would mean an alloy of two of more of Bi, Ag, Cu, or Ni. No Sn alloy powder results from this group of elements. Thus, Paruchuri never contemplates mixing two Sn alloy powders in a lead-free solder paste.

As discussed above, Sakai discloses a solder alloy which in one embodiment contains 92 - 97% Sn, 3 - 6%Ag, and 0.1 - 2% Cu. There is no disclosure or suggestion in Sakai of a solder paste including a plurality of powders of any type.

Therefore, as neither of the cited references discloses or suggests a lead-free solder paste including two different Sn alloy powders, they do not contain teachings capable of being combined to result in a solder paste having all the features set forth in claim 3 and included in claims 4 - 12, 14 - 16, 19, and 20 which depend from claim 3 and so cannot render these claims obvious.

Claim 3 has still other features which are not taught by the cited references. Claim 3 states not only what the composition of a plurality of metal powders in a solder paste would be when melted. It also states that each of two different Sn alloy powders in a plurality of metal powders in a solder paste includes 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn. Since neither Paruchuri nor Sakai deals with a paste containing a

plurality of Sn alloy powders, they necessarily do not teach the composition of individual Sn alloy powders in a plurality of metal powders. Even if (a) it were assumed that Paruchuri suggested a paste containing a plurality of Sn alloy powders (as the Official Action has argued) and (b) it were assumed that it would be obvious to modify Paruchuri such that its overall composition would fall into the range of 1 - 5 mass % Ag, 0.5 - 3 mass % Cu, and a remainder of Sn as defined by claim 3, it would still not follow that each of these hypothetical Sn alloy powders in a modified version of Paruchuri would have a composition falling into the range set forth in claim 3 of 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn set forth in claim 3. This is because there are an infinite number of alloy compositions that can be combined to give a final composition of 1 - 5 mass % Ag, 0.5 - 3 mass % Cu, and a remainder of Sn

To take just two examples, the following hypothetical dual-alloy pastes A and B both have a final composition which falls into the range set forth in claim 3 of 1 - 5 mass % Ag, 0.5 - 3 mass % Cu, and a remainder of Sn, but neither paste satisfies the requirement of claim 3 that each Sn alloy powder include 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn.

<u>Paste A</u>

Paste A comprises the following two Sn alloy powders:

20 parts of 10Ag-9Cu-Sn alloy powder (powder 1)

80 parts of 3Ag-1Cu-Sn alloy powder (powder 2)

Total composition when melted: 100 parts of 4.4Ag-2.6Cu-Sn

<u>Paste B</u>

Paste B comprises the following two Sn alloy powders:

15 parts of 8Ag-8Cu-Sn alloy powder (powder 1)

85 parts of 4Ag-2Cu-Sn alloy powder (powder 2)

Total composition when melted: 100 parts of 4.6Ag-2.9Cu-Sn alloy powder

For each of these pastes, the total composition of the paste satisfies the requirement of claim 3 for the composition of a plurality of powders when melted, but powder 1 does not satisfy the requirement of claim 3 for the composition of the individual powders forming the paste. This demonstrates that two pastes can satisfy a portion of the requirements of claim 3 without satisfying the claim as a whole.

Therefore, merely combining Paruchuri with Sakai as proposed by the Official Action does not automatically result in a solder paste having all the features set forth in claim 3. As the references do not contain teachings from which a person skilled in the art could select the compositions for the individual Sn alloy powders set forth in claim 3, the references do not teach all the features of this claim and so cannot render it or claims 4 - 12, 14 - 16, 19, and 20 which depend from claim 3 obvious.

Claim 4, claim 5, claim 6, and claim 7 are each patentable for the reasons given above with respect to claim 3 from which they depend and are further patentable in their own right. These claims are discussed together for convenience, but they are patentably distinct from each other. Each of these claims further defines the plurality of metal powders recited in claim 3. Claim 4 states that the two Sn alloy powders in claim 3 contain the same components as each other in different proportions, claim 5 states that the plurality of metal powders in claim 3 include two different Sn-Ag-Cu alloy powders, claim 6 states that one of the metal powders of claim 3 is a Sn-Ag alloy powder and another of the metal powders is a Sn-Cu alloy powder, and claim 7 states that the plurality of metal powders in claim 3 include a Sn-Ag alloy powder, a Sn-Cu alloy powder, and a Sn-Ag-Cu alloy powder. Given that Paruchuri does not teach or suggest any composition including two different Sn alloy powders, it necessarily does not suggest the specific compositions set forth in these claims.

Since Paruchuri has specific melting point requirements for the powders which it employs, and since it does not disclose a solder paste with two Sn alloys, there is no evidence that Paruchuri is even enabling for any of the combinations of powders set forth in claims 4 - 7. Claims 4 - 7 are patentably distinct from each other because two Sn alloy powders containing the same components as each other in different proportions (as set forth in claim 4) do not suggest two different Sn-Ag-Cu alloy powders (as set forth in claim 5), a Sn-Ag alloy powder and a Sn-Cu alloy powder (as set forth in claim 6), or a Sn-Ag alloy powder, a Sn-Cu alloy powder, and a Sn-Ag-Cu alloy powder (as set forth in claim 7), or vice versa.

Claims 13 and 15 are patentable for the reasons given with respect to claims 1 - 24 as a whole, and they are further patentable in their own right. These two claims are discussed together for convenience, but they are patentably distinct from each other, since claim 13 depends from claim 1, while claim 15 depends from claim 3, which is patentably distinguished from claim 1 for the reasons discussed above. Claim 13 and 15 each specifies that the plurality of metal powders in claim 1 and claim 3, respectively, have a composition when melted containing at most 1.0 mass % of Cu. In contrast, the lowest Cu content which Paruchuri discloses for its solder paste is 3.0%. As discussed above, Sakai provides no motivation to modify the Cu content of Paruchuri at all, let alone to lower the Cu content to 1/3 of the lowest value which Paruchuri teaches as providing improved fatigue and creep resistance. To lower the Cu content of Paruchuri to the level of 1.0% or less set forth in claim 13 or 15 would require a person skilled in the art to essentially ignore all the teachings of Paruchuri concerning Cu content with no basis in the references to think that doing so would further the objectives of Paruchuri. Thus, the proposed modification of the primary reference is unreasonable, and the rejection of claims 13 and 15 based on this proposed modification is improper.

Claims 16 , 17, and 18 are patentable for the reasons given above with respect to all of claims 1 - 24, and they are further patentable in their own right because the references do not contain teachings that could be combined to result in the methods described by these claims. Claims 16 - 18 are discussed here together for convenience because they include a common feature, but they are patentably distinct from each other. Claim 17, which depends from claim 1, is distinct from claim 18 because claim 1 includes a limitation as to the composition of the solder paste being employed not found in claim 18, and claim 16, which depends from claim 3, is patentably distinct from claims 17 and 18 because claim 3 includes limitations as to the composition of the solder paste being employed not found in claims 17 and 18. Each of claims 16, 17, and 18 describes a reflow soldering method including melting a plurality of different metal powders in a solder paste. As discussed above with respect to Issue 1, in the reflow soldering method disclosed in Paruchuri, a single alloy powder in a solder paste melts during reflow, while the other powders in the solder paste, which are elemental metal powders, remain unmelted in order to provide a large stand-off height and a reinforcing effect (column 2, lines 60 - 67 of Paruchuri). Sakai is relied upon in this rejection for its teaching of a certain alloy composition. Even if Paruchuri were modified as proposed by the Official Action to employ metal powders having the overall composition taught by Sakai, the combined references would still not result in a method including melting a plurality of metal powders, since there is no teaching of doing so in either reference. Thus, as the combined references would not include all the steps of claims 16 - 18, they cannot render these claims obvious.

Claims 19, 21, and 23 are patentable for the reasons given above with respect to all of claims 1 - 24, and they are separately patentable in their own right because the references do not contain teachings that could be combined to result in the methods described by these claims. These three claims are discussed here together for convenience because they include

a common feature, but they are patentably distinct from each other. Claim 21 (which depends from claim 1) is distinct from claim 23 (which depends from claim 18) because claim 1 includes a limitation as to the composition of the solder paste being employed not found in claim 18. Furthermore, claim 19 (which depends from claim 3) is patentably distinct from claims 21 and 23 because claim 3 includes limitations as to the composition of the solder paste being employed not found in claims 1 and 18. Each of claims 19, 21, and 23 describes a reflow soldering method including completely melting the plurality of metal powders in the reflow soldering. As discussed above with respect to claims 16 - 18, neither Paruchuri nor Sakai discloses melting a plurality of metal powders at all during reflow soldering, so they necessarily do not teach <u>completely</u> melting a plurality of metal powders, as in claims 19, 21, and 23.

Paruchuri repeatedly states that in its soldering process, the additive metal powder component does not melt (see, for example column 3, line 34 of Paruchuri). After the words "does not melt", Paruchuri sometimes adds parenthetically "(except for a certain amount of dissolution)". It is the Applicants' position that "a certain amount of dissolution" does not constitute "melting" as set forth in claims 16 - 18, since otherwise Paruchuri would not state that the additive metal powder component does not melt. It is not clear whether the Official Action considers "a certain amount of dissolution" as constituting melting; however, it is clear that "a certain amount of dissolution" cannot constitute <u>complete</u> melting as set forth in claims 19, 21, and 23.

Thus, even if Paruchuri were modified as proposed by the Official Action to employ metal powders having the overall composition taught by Sakai, the combined references would not result in a method including completely melting a plurality of metal powders, so the combined reference would not include all the steps of claims 19, 21, and 23 and thus cannot render these claims obvious.

Claims 20, 22, and 24 further patentably distinguish the present invention from the cited references by specifying that the complete melting is performed in a single reflow step. Given that the references, if combined in the manner proposed in the Official Action, would not teach complete melting of a plurality of metal powders at all, they necessarily would not teach melting the powders in a single reflow step, as set forth in claims 20, 22, and 24. Therefore, the references fail to teach all the steps set forth in these claims and so cannot render them obvious. While claims 20, 22, and 24 are discussed together for convenience, they are patentably distinguished from each other because claim 20 ultimately depends from claim 3, claim 22 ultimately depends from claim 1, and claim 24 ultimately depends from claim 18. Claim 3 includes compositional limitations not found in either claim 1 or claim 18, and claim 1 includes compositional limitations not found in claim 18.

Issue 3 - The rejection of claims 1 - 24 under 35 USC 103(a) over Paruchuri in view of Hitch

For purposes of this rejection only, claims 1 and 2 stand together as a group, and claims 3, 8 - 12, and 14 stand together as a group. These groups of claims are separately patentable from each other, and the remaining claims are separately patentable from these groups of claims and from each other.

This rejection is found beginning at the bottom of page 11 of the Official Action of October 17, 2002. As is the case with respect to the previous rejection, the initial statement of the rejection on page 11 indicates that it applies only to claims 1 - 18, but since pages 12 and 13 of the Official Action also refer to claims 19 - 24, it is assumed that the rejection applies to all of claims 1 - 24.

As is the case with the previous rejection, this rejection is erroneous for failing to set forth a *prima facie* case of obviousness because there is no motivation in the references to combine them in the manner proposed by the Official Action. The rejection is further erroneous because the references do not teach all of the features of the rejected claims.

As discussed above, Paruchuri, the primary reference, discloses a lead-free solder paste in which Cu, in one embodiment, represents 3 - 10% of the total metal weight of its solder paste. Column 3, lines 59 - 67 of Paruchuri disclose that a solder composition with this level of Cu has improved fatigue and creep resistance.

The secondary reference in this rejection is Hitch, which discloses a soldering composition in which copper is added to an Sn-Ag alloy to produce a nearly eutectic Sn-Ag-Cu ternary alloy, to which additional elements may be added. According to page 2, line 2 of Hitch, a preferred composition of the ternary alloy is 95.8Sn - 3.5Ag-0.67Cu.

The Official Action proposes modifying the solder paste of Paruchuri to employ the composition of Hitch, with a Cu content of 0.5 - 2.7%, because, according to the Official Action, Hitch teaches that a solder joint of this composition has "superior properties".

This proposed modification of Paruchuri in light of Hitch is not reasonable for the same reasons that the proposed modification of the Paruchuri reference in light of Sakai (as discussed in Issue 2) is not reasonable. Namely, (a) Hitch provides no evidence that its composition is superior to or even comparable to that of Paruchuri, and (b) Hitch discloses a composition which functions metallurgically in a totally different manner from the composition disclosed by Paruchuri.

As for point (a), the table on page 3 of Hitch states that a 95.8Sn-3.5Ag-0.67Cu alloy has "excellent solderability" on Cu, fatigue which is the "best of alloys shown", and "very good" corrosion. However, there attributes are all in qualitative terms and without any reference point. There is no evidence that the solderability, fatigue, or corrosion of these alloys are any better than, or even as good as, those of the solder paste taught by Paruchuri. Even the description "best of alloys shown" in the table is meaningless in comparing Hitch to Paruchuri, since all of the "alloys shown" in the table have a Cu content which ranges only from 0.4% to 1.5%, so the alloys provide no evidence that a composition with a Cu content of this level is superior to that employed in Paruchuri having a Cu content of 3 - 10%.

As for point (b), Paruchuri and Hitch relate to fundamentally different types of solder compositions (just as the compositions of Paruchuri and Sakai are fundamentally different from each other in nature). As discussed above with respect to Issue 2, Paruchuri relates to a solder composition having multiple powders in which the primary powder melts while the additive powder <u>does not melt</u>. As a result, the additive powder does not form an alloy with the primary powder but instead remains as a powder, embedded in a matrix formed by the melting of the primary powder. The fact that the additive powder in Paruchuri does not alloy with the primary powder is the basis on which the invention of Paruchuri was distinguished over the prior art during the prosecution of the patent application which issued as the Paruchuri patent. Page 6 of a response filed on March 19, 1998 in connection with that patent application (08/827,589) contains the following argument in which it distinguishes

its invention from a reference (Vianco). The argument deals with the case in which the primary alloy powder is Sn-Ag or Sn-Pb-Ag and the additive powder is Bi, but the principles which it states apply in general to the solder paste of Paruchuri:

> The invention does not claim an alloy containing Bi as required by Vianco. In the current invention, the solder is not heated above the melting temperature of Bi (271°C) in order to alloy the Bi with either Sn-Ag or Sn-Pb-Ag. The claimed invention incorporates the Bi in an elemental (unmelted) state. Bi does not form an alloy with the Sn-Ag.

Hitch, on the other hand, relates to a single-powder solder paste in which all the metal components in the solder paste form a single alloy. There is no teaching in either reference that a solder joint produced by a multiple-powder composition (like the solder joint of Paruchuri) in which the powders do not alloy with each other has the same metallurgical characteristics as a solder joint formed from a single alloy powder (like a solder joint formed from the alloys disclosed in Hitch) and no reason to think that any metallurgical considerations described by Hitch would have any relevance to the multiple-powder solder composition of Paruchuri. A person skilled in the art would find no reason to even consult Hitch in considering how to improve the solder composition of Paruchuri and accordingly no motivation to modify Paruchuri based on Hitch.

Thus, as Paruchuri and Hitch provide no motivation to combine them in the manner proposed in the Official Action, the grounds of rejection of claims 1 - 24 fail to set forth a *prima facie* of obviousness and are improper.

Independent claim 3 is allowable for the reasons given above with respect to all of claims 1 - 24 (i.e., for lack of motivation to combine the references), and it further patentably distinguishes the invention from the cited references because the references fail to disclose or suggest all the features of this claim. As discussed above, claim 3 describes a lead-free solder paste including two different Sn alloy powders. Neither of the cited references discloses or suggests such a composition. As set forth at length with respect to

Issue 2, Paruchuri discloses a solder composition including a primary powder in the form of an Sn alloy and an additive powder in the form of an elemental metal, such as elemental Ag, Cu, Ni, or Bi, and there is no contemplation in Paruchuri of a solder paste containing more than one Sn alloy powder. Hitch was relied upon as teaching a solder composition having a Cu content of less than 3%. There is no teaching or suggestion in Hitch concerning a solder paste containing multiple metal powders of any type.

Even if it were obvious to modify the Paruchuri references so as to have the overall composition of the alloy disclosed in Hitch, and even if it were obvious to employ two Sn alloy powders in the solder paste of Paruchuri, there would still be no teaching in the references of the composition of the individual Sn alloy powders employed in claim 3. Namely, there would be no teaching of two different Sn alloy powders each including 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn as specified in claim 3. As explained with respect to Issue 2, there are an infinite number of combinations of two Sn alloy powders which could provide the overall composition of 1 - 5 mass % Ag, 0.5 - 3 mass % Cu, and a remainder of Sn set forth in claim 3, with one or both of the Sn powders falling outside the range for the individual powders (0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn) set forth in claim 3. In view of the lack of a single example in either Paruchuri or Hitch of combining two Sn alloy powders in a solder paste, a person skilled in the art could not know from the references to select, out of the infinite number of possible combinations, two Sn alloys having the compositions set forth in claim 3, i.e., 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn. When references fail to disclose all the features set forth in a claim, they necessarily cannot render that claim obvious. The rejection of claim 3 over Paruchuri and Hitch is thus improper.

Each of claims 4, 5, 6, and 7 is patentable for the reasons given above with respect to claim 3, and each is further and separately patentable in its own right. Each of claims 4 - 7

describes a specific combinations of Sn alloys for the two different An alloy powders of claim 3. Given that neither Paruchuri nor Hitch teaches or suggests any composition including two different Sn alloy powders, they necessarily do not teach or suggest the specific compositions set forth in claims 4 - 7. These claims are thus patentable independently of claim 3, and for the reasons set forth with respect to Issue 2, they are patentable independently of each other.

Claims 13 and 15 are patentable for the reasons set forth above concerning claims 1 - 24 as a whole, and they are further patentable in their own right. While these two claims will be discussed together, they are patentably distinct from each other for the reasons explained with respect to Issue 2. Claims 13 and 15 state that the plurality of metal powders in claim 1 and claim 3, respectively, have a composition when melted containing at most 1.0 mass % of Cu. The lowest Cu content which Paruchuri discloses for its solder paste is 3.0%. As discussed above, Hitch does not provide any motivation to modify the Cu content of Paruchuri at all, and certainly not to lower the Cu content to 1/3 of the lowest value which Paruchuri teaches. A person skilled in the art would need to ignore all the teachings of Paruchuri concerning Cu content in order to lower the Cu content of Paruchuri to the level of 1.0% or less set forth in claim 13 or 15, and there is no motivation in the references to do so, as there is no indication that doing so would further or even meet the objectives of Paruchuri. As such, the proposed modification of the primary reference is not reasonable, so the rejection of claims 13 and 15 based on this proposed modification is improper.

Claims 16 - 18 are allowable for lack of motivation to combine the cited references as set forth above, and they are further allowable in their own right because the references fail to teach or suggest all the features of the methods described by these claims. Claims 16 - 18 are again discussed together for convenience, but these claims are patentably distinct from

each other for the reasons set forth in the discussion of these claims in Issue 2. Each of claims 16 - 18 describes a reflow soldering method including melting a plurality of powders in a solder paste. As discussed at length with respect to both Issue 1 and Issue 2, in the reflow soldering method of the Paruchuri reference, a single alloy powder in a solder paste (the primary powder) melts during reflow, while the other powder in the solder paste (the additive powder) must remain unmelted in order to provide a large stand-off height and a reinforcing effect (column 2, lines 60 - 67 of Paruchuri). Hitch is relied upon in this rejection for its teaching of a certain alloy composition having a Cu content of 0.5 - 2.7%. Even if Paruchuri were modified as proposed by the Official Action to employ metal powders having an overall composition the same as that of the single-alloy powder taught by Hitch, the combined references would still not result in a method including melting a plurality of different metal powders, since there is no teaching of doing so in either reference. Thus, as the combined reference would not include all the steps of claims 16 - 18, they cannot render these claims obvious.

Claims 19, 21, and 23 are allowable as depending from independent claims 3, 1, and 18, respectively, and are separately allowable in their own right because the references do not contain teachings that could be combined to result in the methods described by these claims. While these claims are discussed together for brevity, they are patentable separately from each other for the reasons set forth with respect to these claims in Issue 2. Each of claims 19, 21, and 23 describes a reflow soldering method including completely melting the plurality of metal powders in solder paste being employed during the reflow soldering. As discussed above with respect to claims 16 - 18, neither Paruchuri nor Hitch discloses melting a plurality of metal powders at all during reflow soldering, so they necessarily do not teach completely melting a plurality of metal powders, as set forth in claims 19, 21, and 23.

Thus, even if Paruchuri were modified as proposed by the Official Action to employ

metal powders having an overall composition the same as that of the single-alloy powder taught by Hitch, the combined references would still not result in a method including completely melting a plurality of metal powders, so the combined references would not include all the steps of claims 19, 21, and 23 and thus cannot render these claims obvious.

Claims 20, 22, and 24 further patentably distinguish the present invention from the cited references. These claims are discussed together because they add a common feature to the respective claims from which they depend, but they are patentably distinct from each other for the reasons set forth in the discussion of these claims in Issue 2. Each of claims 20, 22, and 24 specifies that the complete melting of claim 19, 21, or 23 is performed in a single reflow step. Given that the references, as combined in the manner proposed in the Official Action, would not include complete melting of a plurality of metal powders at all, they necessarily would not include melting the powders in a single reflow step, as set forth in claims 20, 22, and 24. Therefore, the references fail to teach all the steps set forth in these claims and so cannot render them obvious.

<u>Issue 4 - The rejection of claims 3 - 12, 14 - 16, 18 - 20, 23, and 24 under 35 USC 103(a) over Kazem-Goudarzi in view of Seelig and further in view of Sakai</u>

For purposes of this rejection only, claims 3, 8, 11, 12, 14 - 16, 18, 19, and 23 stand together, and claims 20 and 24 stand together. These groups of claims are separately patentable from each other, and the remaining claims are separately patentable from these groups of claims and from each other.

This rejection is found on page 13 of the Official Action of October 17, 2002. The initial statement of the rejection on page 13 of the Official Action indicates that the rejection applies only to claims 3 - 12, 14 - 16, and 18, but since page 14 of the Official Action also refers to claims 19, 20, 23, and 24, it is assumed that the rejection applies to these claims as well.

This rejection is erroneous in that it fails to set forth a *prima facie* case of obviousness because there is no motivation in the references to combine them in the manner proposed by the Official Action. The rejection is additionally erroneous because the references do not teach or suggest all of the features of the rejected claims.

The primary reference in this rejection is Kazem-Goudarzi, which discloses a soldering process employing a dual-alloy solder paste containing two different types of solder alloys. A solder paste containing a low temperature alloy 115 and a high temperature alloy 120 is applied to a solderable surface of a printed circuit board 100. The paste is then heated to a temperature to melt (reflow) the low temperature alloy 115 but not the high temperature alloy 120 so as to form a solid solder mass having a flat textured surface. A surface mounted part is then placed on a desired location in contact with the solid solder mass, and then heating (reflow) is carried out a second time at a higher temperature than before in order to remelt the low temperature alloy 115 and then melt the high temperature alloy 120. It is important for the two alloys 115 and 120 to have unique melting ranges so that one alloy can be melted without melting the other alloy during the first reflow step.

Kazem-Goudarzi gives only specific example of the two solder alloys, which are a Sn-Pb-Ag alloy having a melting point of 179 - 181 °C and a Sn-Pb-Bi alloy having a melting range of 144 - 163 °C (column 4, lines 3 - 10).

Seelig, one of two secondary references in this rejection, discloses a solder alloy composition for electronic assembly applications containing 93 - 98% tin, 1.5 - 3.5% silver, 0.2 - 2.0% copper, and 0.2 - 2.0% antimony.

The other secondary reference in this rejection is Sakai. As described above with respect to Issue 2, Sakai discloses various lead-free solders for joining electronic parts, among which is a solder alloy containing 92 - 97% Sn, 3 - 6% Ag, and 0.1 - 2% Cu.

Page 14 of the Official Action proposes to combine these references as follows: "It would have been obvious to modify the dual-alloy paste of Kazem-Goudarzi et al. by using alloys of tin with copper and/or silver to arrive at a final composition such as that taught by Sakai et al. because Seelig et al. teaches removing the lead and bismuth and using Sn-Ag-Cu instead, while Sakai et al. teaches that the specific Sn-Ag-Cu compositions exhibit superior properties."

Thus, the Official Action proposes to modify Kazem-Goudarzi so as to employ dual alloys having a final composition which is a Sn-Ag-Cu alloy because Seelig supposedly teaches using a Sn-Ag-Cu alloy, and the Official Action proposes to further modify Kazem-Goudarzi such that the final Sn-Ag-Cu composition would be a 92 - 97% Sn, 3 - 6% Ag, and 0.1 - 2% Cu composition, which is one of the compositions taught by Sakai for a single-alloy solder paste.

A first error in this rejection is that it mischaracterizes the teachings of Seelig. The Official Action erroneously relies on Seelig as proposing a Sn-Ag-Cu alloy as an alternative to prior art solder alloys containing lead and bismuth. What Seelig actually teaches is a solder alloy having antimony as an essential element, i.e., it teaches an Sn-Ag-Cu-Sb alloy. There is nothing in Seelig to suggest to a person skilled in the art to employ a Sn-Ag-Cu

alloy in the soldering process of Kazem-Goudarzi.

Page 8 of the Official Action questions whether antimony might be present only as an impurity in Seelig. Antimony is often alloyed with lead, particularly for use in lead-acid batteries for automobiles, so antimony could conceivably be present as an impurity in lead recovered from such batteries. However, Seelig relates to a lead-free alloy, so it contains no lead in which antimony could be an impurity, and antimony is not an impurity of any of the other three elements besides antimony (Sn, Cu, Ag) employed in Seelig. Therefore, antimony can be present in the solder of Seelig only by design. Page 7 of the Official Action also questions whether antimony qualifies as an essential component of Seelig when its content is 0.2 - 2.0%. To this question, the answer must be that since Seelig only discloses alloys containing antimony, then antimony is by definition an essential component of the invention of Seelig.

A second error in this rejection is that there is no teaching in either Seelig or Sakai that there exist solder alloys which are capable of meeting the requirements of Kazem-Goudarzi and at the same time of giving a final alloy composition of 92 - 97% Sn, 3 - 6% Ag, and 0.1 - 2% Cu (the alloy composition which the Official Action proposes to employ in Kazem-Goudarzi). In the method of Kazem-Goudarzi, which employs a dual-alloy solder paste, it is important for the two alloys of the dual-alloy solder paste to having unique melting ranges so that one alloy can be melted without simultaneously melting the other alloy. Kazem-Goudarzi does not define how far apart the melting ranges of the two alloys must be, but in the one specific example of alloys given in Kazem-Goudarzi (column 4, lines 6 - 8), the melting ranges of the two alloys differ by at least 16°C (144 - 163°C for one alloy, and 179 - 181°C for the other alloy).

Sakai teaches only single-alloy solder pastes, and it teaches nothing about combining alloys with each other in a dual-alloy solder paste. There may in fact be Sn alloys that could be combined with each other to provide a final composition of 92 - 97% Sn, 3 - 6% Ag, and

0.1 - 2% Cu (the composition set forth in Sakai) and which have melting ranges sufficiently different from each other to satisfy the requirements of the method of Kazem-Goudarzi, but whether such alloys exist is not taught by any of the three cited references, since none of these reference relates to combining Sn alloys in a dual-alloy paste to obtain a final composition which is a Sn-Ag-Cu alloy. Namely, a person skilled in the art could not know from any of the references whether it is possible to modify the method of Kazem-Goudarzi to achieve a Sn-Ag-Cu alloy composition, and in particular the 92 - 97% Sn, 3 - 6% Ag, and 0.1 - 2% Cu alloy composition taught by Sakai, while still enabling the modified method to function in the intended manner such that the two alloys which it employs do not melt at the same time. Moreover, not only do the references fail to teach that this end result (a 92 - 97% Sn, 3 - 6% Ag, 0.1 - 2% Cu alloy composition) is possible, they do not teach any alloys for achieving this end result.

Therefore, as Seelig does not teach anything about employing an Sn-Ag-Cu alloy, a person skilled in the art would receive no motivation from Seelig to employ such an alloy in Kazem-Goudarzi. Furthermore, as the three references do not teach either the feasibility of modifying the method of Kazem-Goudarzi so as to achieve the Sn-Ag-Cu alloy set forth in Sakai as a final composition or how such a composition could be achieved, the references provide no motivation to a person skilled in the art to modify Kazem-Goudarzi such that the final composition of the dual-alloy solder paste which it employs would be 92 - 97% Sn, 3 - 6% Ag, and 0.1 - 2% Cu. Accordingly, as the cited references provide no motivation to combine them in the manner proposed in the Official Action, the Official Action fails to set forth a *prima facie* case of obviousness in this rejection, so the rejection of all of claims 3 - 12, 14 - 16, 18 - 20, 23, and 24 is improper.

The rejection is further erroneous because the references fail to teach or suggest all the features of the rejected claims. As discussed above with respect to Issue 2, independent

claim 3 sets forth not only the overall composition of a plurality of powders in a solder paste, it also sets forth the composition of individual Sn alloy powders in the plurality of metal powders. Specifically, claim 3 states that each of two Sn alloy powders includes 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn. Nowhere do the cited references teach that a plurality of Sn alloy powders should have such a composition. As described above, Kazem-Goudarzi gives one example of two alloy powders which can be employed in its paste, these being a Sn-Pb-Ag alloy and a Sn-Pb-Bi alloy. Kazem-Goudarzi teaches nothing about the Sn alloy powders set forth in claim 3. Seelig discloses a solder alloy composition for electronic assembly applications containing 93 - 98% tin, 1.5 - 3.5% silver, 0.2 - 2.0% copper, and 0.2 - 2.0% antimony, and it teaches nothing about the Sn alloy powders of claim 3. Sakai is relied upon as teaching a solder paste having a composition in the range of the <u>overall</u> composition of the metal powders set forth in claim 3 when melted, and the Official Action proposes to modify Kazem-Goudarzi to employ alloys having this final composition. However, since Sakai relates to a single-alloy solder, it teaches nothing about how to choose individual alloys for use in the dual-alloy solder paste employed in the method of Kazem-Goudarzi, so even if a person skilled in the art were to modify the method of Kazem-Goudarzi such that the final composition of the powders in its dual-alloy solder paste was the composition which Sakai teaches for a solder alloy, there is nothing in the references that would suggest choosing the individual powders to be combined such that each powder includes 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass %. As discussed above with respect to Issue 2, there are an infinite number of combinations of alloy powders that could be combined to result in the overall composition after melting set forth in claim 3 of 1 - 5 mass % Ag, 0.5 - 3 mass % Cu, and a remainder of Sn, and there are an infinite number of these combinations in which at least one powder falls outside the range for the individual powders given in claim 3 of 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass %.

Thus, as there are no teachings in the references from which a person skilled in the art could select the specific ranges for the compositions of the individual Sn alloy powders employed in claim 3, the combined references fail to teach or suggest all the features of claim 3 or claims 4 - 12, 14 - 16, 19, and 20 which depend from it.

In the same manner, the references fail to teach or suggest all of the features of independent claim 18. Claim 18 describes a method of soldering employing a solder paste. Claim 18 specifies the composition of the plurality of powders in the paste when melted, and it specifies the composition of each Sn alloy powder in the paste as being 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass %, which is the same composition set forth in claim 3. As just discussed with respect to claim 3, none of the references relates to combining powders in a solder paste to obtain an Sn-Ag-Cu composition, so they do not teach a person skilled in the art which powders could or should be combined to obtain a specific Sn-Ag-Cu composition when melted. The Official Action proposes to modify Kazem-Goudarzi to employ powders such that the overall composition of the resulting solder paste would be an Sn-Ag-Cu composition set forth in Sakai. However, since there are an infinite number of ways to combine two powders to obtain the Sn-Ag-Cu composition of Sakai without satisfying the requirements of claim 18 that each Sn alloy powder in the composition contain 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass %, modifying Kazem-Goudarzi as proposed by the Official Action would not automatically result in a solder paste having all the features set forth in claim 18. Namely, without further teachings which are lacking from the cited references, Kazem-Goudarzi cannot be modified so as to satisfy all the requirements of claim 18 or of claims 23 and 24 which depend from it.

Accordingly, as there is no motivation to combine the cited references as proposed by the Official Action, and as the combined references would still not include all the features recited in the claims, the cited references cannot render any of claims 3 - 12, 14 - 16, 18 -

20, 23, and 24 obvious.

Dependent claims 4 - 7 are patentable for the reasons given above with respect to claim 3 and are separately patentable in their own right. These claims are patentably distinct from each other for the reasons stated with respect to these claims in Issue 2. As set forth above, each of these claims describes a different, specific combination of Sn alloys for the two different Sn alloy powders set forth in claim 3. Namely, claim 4 states that the two Sn alloy powders in claim 3 contain the same components as each other in different proportions, claim 5 states that the plurality of metal powders in claim 3 include two different Sn-Ag-Cu alloy powders, claim 6 states that one of the metal powders of claim 3 is a Sn-Ag alloy powder and another of the metal powders is a Sn-Cu alloy powder, and claim 7 states that the plurality of metal powders in claim 3 include a Sn-Ag alloy powder, a Sn-Cu alloy powder, and a Sn-Ag-Cu alloy powder. None of the cited references teaches or suggests these combinations of alloy powders. The only specific examples of solder powders given in Kazem-Goudarzi are a tin-lead-silver alloy as a high temperature alloy and a tin-lead-bismuth alloy as a low temperature alloy. Seelig discloses a tin-silver-copper-antimony alloy and nowhere suggests any of the alloy combinations set forth in claims 4 - 7. Sakai teaches various alloys, among which are Sn-Ag-Cu solder alloys. Although the Official Action argues that it would have been obvious from Sakai to have modified Kazem-Goudarzi so that the final composition of the solder alloy resulting from the method of Kazem-Goudarzi would be a Sn-Ag-Cu alloy, Sakai is unrelated to a combination of different solder alloy powders and teaches nothing about what combination of solder powders might be employed in the method of Kazem-Goudarzi to obtain a Sn-Ag-Cu, and it certainly neither teaches nor suggests any of the specific combinations of alloy powders set forth in claims 4 - 7.

Therefore, the references do not contain teachings that could be combined to result in any of the combinations of solder alloy powders set forth in claims 4 - 7 and so cannot

render these claims obvious.

Claims 9 and 10 are patentable for the reasons given with respect to claim 3, and they are further patentable in their own right. Claim 9 describes a method of soldering using the solder paste of claim 3 at a reflow temperature of at most 250°C, and claim 10 describes a method of soldering using the solder paste of claim 3 at a reflow temperature of at most 240°C. The references contain no teachings that could be combined to result in a method having these features.

The method of Kazem-Goudarzi involves reflow soldering of a dual-alloy solder paste containing two different alloys (a low temperature alloy 115 and a high temperature alloy 120) to melt the alloys in two reflow steps. The highest reflow temperature in this method must be higher than the melting range of the high temperature alloy 120 in order to melt both alloys. Before a person skilled in the art can determine what reflow temperature to use in the method of Kazem-Goudarzi, he needs to know the composition (and therefore the melting ranges) of the individual alloys (the low temperature alloy 115 and the high temperature alloy 120) forming the dual-alloy solder paste. The overall composition of the solder paste at the completion of melting (i.e., the composition after the two starting alloys of Kazem-Goudarzi have been converted into a single alloy) plays no part in determining the reflow temperature in Kazem-Goudarzi, since the melting point of an alloy having this overall composition will be totally different from the melting points of the dual alloys which are employed in the method (just as the melting point of an alloy is often totally different from the melting points of the individual elements making up the alloy).

Thus, it cannot be obvious to select a certain reflow temperature for use in the method of Kazem-Goudarzi unless the dual alloys for use in the method are themselves obvious. As discussed above with respect to claim 3, the secondary references (Seelig and Sakai) both relate to a single-alloy solder paste and do not teach any alloys which it would be

obvious to use as the dual alloys in the dual-alloy solder paste of Kazem-Goudarzi. As the alloys themselves are not obvious, the reflow temperatures, which are determined by those alloys, cannot be obvious. Claims 9 and 10 are therefore not obvious from the cited references.

Regarding claims 9 and 10, page 15 of the Official Action points out Sakai teaches a composition having a melting point of 237-245°C. This melting point is of no relevance to a person skilled in the art in determining what reflow temperature to use in the method of Kazem-Goudarzi. Sakai is being relied upon in this rejection as teaching an overall composition for the dual-alloy solder paste of Kazem-Goudarzi, and as explained above, it is not the overall composition of the dual-alloy solder paste, it is the melting points of the individual dual alloys which determine the reflow temperature. Since no individual dual alloys are identified by the references, it is pure conjecture as to what their melting points and therefore the reflow temperature to be employed would be.

The ability of a solder paste according to the paste according to the present invention to undergo reflow soldering at 250°C or less or 240°C or less provides a significant advantage in that it reduces the chances of thermal damage to components undergoing soldering. As stated on page 2 of the specification of the present application, the reflow temperature employed in reflow soldering with a solder paste is usually 40 - 50°C higher than the melting point of the solder in the solder paste in order to obtain optimal spreading and decrease soldering defects. A single-alloy solder paste having the overall composition of the solder paste set forth in claim 3 would require a much higher melting point in order to avoid defects than the reflow soldering temperatures set forth in claims 9 and 10. For example, Comparative Examples 1 and 2 in Table 1 of the present application have an overall composition falling into the range for the overall composition set forth in claim 3, but since they are single-alloy solder pastes, they produced a high level of defects when reflowed at 240°C. In contrast, the Examples in the Table of solder pastes according to the present

invention, which are multiple-alloy solder pastes, had a low level of defects when reflowed at the same low temperature of 240°C.

Claims 20 and 24 are each patentable for the reasons given above with respect to claims 3 and 18 from which they depend, and each is further patentable in its own right. Dependent claims 20 and 24 each describe a method including completely melting the plurality of metals powders (defined in claim 3 or claim 18, respectively) in a single reflow step. The cited references do not teach or suggest such a method.

As stated above, Kazem-Goudarzi describes a soldering process in which a dual-alloy solder paste containing two different solder powders is melted in two reflow steps. As described in column 4, line 30 - column 5, line 66 of Kazem-Goudarzi, a dual-alloy solder paste is applied to a printed circuit board 100 by printing. At this point, as schematically shown in Figure 2 of Kazem-Goudarzi, the dual-alloy solder paste is a mixture of particles of a low temperature alloy 115, particles of a high temperature alloy 120, and additional components 118 (fluxes or vehicles). During a first reflow step described in column 4, lines 48 - 51, the solder paste is heated to a temperature such that the low temperature solder alloy 115 is melted or liquified and such that the high temperature alloy 120 remains in its original unmelted state. When the low temperature alloy 120 is allowed to solidify, what results is an aggregate-like structure of particles of the unreflowed high temperature alloy 120 distributed within a matrix of the reflowed or melted low temperature solder alloy 115. At this point, as shown in Figure 3, there are no longer any particles of the low temperature alloy 115, since the low temperature alloy has been converted into a solid solder mass (column 4, lines 57 - 58).

Then, in a second reflow step, the aggregate-like structure of Figure 3 is heated to remelt the low temperature alloy 115 and then to melt the high temperature alloy 120 for the first time. What results is a third alloy 200 which is essentially uniform throughout, as

shown in Figure 4. During the second, high temperature reflow step, since particles of the low temperature alloy 115 no longer exist (having been converted into a matrix in the first reflow step), the only solder particles which are melted are particles of the high temperature alloy 120. Thus, Kazem-Goudarzi melts particles of the low temperature alloy 115 only in the first reflow step, and it melts particles of the high temperature alloy 120 only in the second reflow step. Kazem-Goudarzi never melts a plurality of different types of powders in a single reflow step, as set forth in claims 20 and 24.

The Official Action proposes to modify the method disclosed in Kazem-Goudarzi by replacing the two alloy powders used in Kazem-Goudarzi (a tin-lead-silver alloy and a tin-lead-bismuth alloy) with two Sn alloy powders having a combined composition of 92 - 97% Sn, 3 - 6% Ag, and 0.1 - 2%Cu, which is an alloy composition taught by Sakai. However, even if the method of Kazem-Goudarzi were modified as proposed by the Official Action, the resulting method would still require that only particles of one alloy be melted in a first reflow step, and that only particles of the other alloy be melted in a second reflow step, since this melting of particles in two different reflow steps is the very essence of the method of Kazem-Goudarzi, regardless of the composition of the different alloys. Therefore, the resulting method would not include completely melting a plurality of different metal powders in a single reflow step as set forth in claim 20 or claim 24. Thus, the references lack teachings that could be combined to result in a method including all the steps of claims 20 and 24 and so cannot render these claims obvious. The rejections of these claims must therefore be reversed.

<u>Issue 5 - The rejection of claims 3 - 12, 14 - 16, 18 - 20, 23, and 24 under 35 USC 103(a) Kazem-Goudarzi in view of Seelig and further in view of Hitch</u>

For purposes of this rejection only, claims 3, 8, 11, 12, 14 - 16, 18, 19, and 23 stand together, and claims 20 and 24 stand together. These groups of claims are separately patentable from each other, and the remaining claims are separately patentable from these groups of claims and from each other.

This rejection is found on page 15 of the Official Action of October 17, 2002. Page 15 indicates that the rejection applies only to claims 3 - 12, 14 - 16, and 18, but page 16 of the Official Action also refers to claims 19, 20, 23, and 24, so the rejection is assumed to also apply to these claims.

This rejection is erroneous in that it fails to set forth a *prima facie* case of obviousness because there is no motivation in the references to combine them in the manner proposed by the Official Action. The rejection is additionally erroneous because the references do not teach all of the features of the rejected claims.

The primary reference in this rejection is once again Kazem-Goudarzi. The features of this reference are discussed above with respect to Issue 4, so will not be repeated here.

Seelig is again applied as one of two secondary references, as in Issue 4. The features of Seelig are set forth in the discussion of Issue 4.

The other secondary reference in this rejection is Hitch, cited in the rejection of Issue 3. As discussed above with respect to Issue 3, Hitch discloses a variety of soldering compositions, among which are ones containing 3.1 - 3.5% silver, 0.5 - 2.7% copper, and a balance of tin.

Page 15 of the Official Action proposes to combine these references as follows: "It would have been obvious to modify the dual-alloy paste of Kazem-Goudarzi et al. by using alloys of tin with copper and/or silver to arrive at a final composition such as that taught by Hitch et al. because Seelig et al. teaches removing the lead and bismuth and using Sn-Ag-Cu

instead, while Hitch et al. teaches that the specific Sn-Ag-Cu compositions exhibit superior properties."

In other words, the Official Action proposes to modify Kazem-Goudarzi so as to employ dual alloys having a final composition which is a Sn-Ag-Cu alloy because Seelig supposedly teaches using a Sn-Ag-Cu alloy, and the Official Action proposes to further modify Kazem-Goudarzi such that the final Sn-Ag-Cu composition would be a 93.8 - 96.4% Sn, 3.1 - 3.5% Ag, and 0.5 - 2.7% Cu composition, which is a composition taught by Hitch.

As is the case with respect to Issue 4, a first error in this rejection is that it mistakenly relies on Seelig as supposedly proposing a Sn-Ag-Cu alloy as an alternative to prior art solder alloys containing lead and bismuth, whereas in fact Seelig only teach alloys in which antimony is an <u>essential element</u>. No person skilled in the art could come away from Seelig with a motivation to use anything except a solder composition containing antimony.

Another error in this rejection is that neither Seelig nor Hitch (like Sakai in the rejection of Issue 4) teaches that there exist any alloys which could be employed as the dual alloys in the dual-alloy solder paste of Kazem-Goudarzi which would result in a final composition of 93.8 - 96.4% Sn, 3.1 - 3.5% Ag, and 0.5 - 2.7% Cu (the composition disclosed in Hitch which the Official Action proposes to employ in Kazem-Goudarzi) and would also meet the requirements of the method of Kazem-Goudarzi. As set forth in the discussion of Issue 4, Kazem-Goudarzi requires that the dual alloys of its dual-alloy solder paste have unique melting ranges so that one alloy can be melted without simultaneously melting the other. Seelig teaches nothing about any alloys capable of providing a Sn-Ag-Cu composition. Hitch pertains to a single-alloy solder paste and nowhere teaches anything about selecting the individual alloys of a dual-alloy solder paste. Whether or not there exist solder alloys which have melting ranges sufficiently different from each other for them to be used in Kazem-Goudarzi and which would also provide a final alloy composition of 93.8 -

96.4% Sn, 3.1 - 3.5% Ag, and 0.5 - 2.7% Cu is not disclosed by Hitch.

It may be noted in passing that the only specific Sn-Ag-Cu alloys disclosed by Hitch (Examples 1 - 3) have melting ranges of 213 - 218°C, 214 - 215°C, and 214 - 216°C, respectively. The melting ranges of these alloys are virtually identical, meaning that dual alloys for use in the method of Kazem-Goudarzi could not be selected from among these exemplary alloys of Hitch, since the method of Hitch could not be performed in the intended manner.

Thus, a person skilled in the art could not know from the cited references either whether it is possible or how to modify Kazem-Goudarzi so as to obtain a final composition of 93.8 - 96.4% Sn, 3.1 - 3.5% Ag, and 0.5 - 2.7% Cu (a composition taught by Hitch) while satisfying the requirement of the method of Kazem-Goudarzi that the dual alloys having unique melting ranges.

Therefore, as Seelig does not teach anything about employing an Sn-Ag-Cu alloy, a person skilled in the art would receive no motivation from Seelig to employ such an alloy in Kazem-Goudarzi, and as neither Seelig nor Hitch teaches the existence of alloys both suitable for the purposes of Kazem-Goudarzi and providing a final composition of 93.8 - 96.4% Sn, 3.1 - 3.5% Ag, and 0.5 - 2.7% Cu, a person skilled in the art would receive no motivation from these reference to modify Kazem-Goudarzi as proposed by the Official Action. Accordingly, as the cited references provide no motivation to combine them in the manner proposed in the Official Action, the Official Action fails to set forth a *prima facie* case of obviousness in this rejection, so the rejection is improper.

The rejection is additionally erroneous for the reason that the references do not teach all the features of the rejected claims. Independent claim 3 states that each of a plurality of Sn alloy powders in a solder paste includes 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn. The method described by independent claim 18 includes employing a solder paste including a plurality of powders, with each Sn alloy powder in the plurality of

powders including 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn. The cited references contain no teachings from which a person skilled in the art could derive these features of claims 3 and 18. Kazem-Goudarzi discloses a dual-alloy solder paste. The only specific examples of compositions of the dual alloys which it gives are a Sn-Pb-Ag alloy and a Sn-Pb-Bi alloy, so it fails to teach the composition for each Sn alloy powder in a paste set forth in claims 3 and 18. Seelig discloses a solder alloy composition for electronic assembly applications containing 93 - 98% tin, 1.5 - 3.5% silver, 0.2 - 2.0% copper, and 0.2 - 2.0% antimony, so it only teaches a solder alloy with antimony as an essential ingredient, and it teaching nothing about the selection of individual powders for use in a Sn-Ag-Cu solder paste. Hitch discloses a number of alloy compositions, but each of these composition is for a <u>single-alloy</u> solder paste. Hitch teaches nothing about how to select individual Sn alloys for use in a dual-alloy solder paste, like the dual-alloy solder paste employed in the method of Kazem-Goudarzi.

It should be noted that although the Sn-Ag-Cu alloys identified as Examples 1 - 3 on pages 3 and 4 of Hitch each have a composition falling into the range of 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn defined in claims 3 and 18, as stated above, Examples 1 - 3 could not be used as the dual alloys of the dual-alloy solder paste of Kazem-Goudarzi because their melting points are virtually identical with each other, and Kazem-Goudarzi requires powders having significantly different melting points from each other. Therefore, these Examples do not teach a person skilled in the art to employ Sn alloy powders in Kazem-Goudarzi having the compositions set forth in claims 3 and 18.

Thus, there is nothing in the references that would suggest choosing the individual alloy powders in the dual-alloy solder paste of Kazem-Goudarzi such that each Sn alloy powder includes 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass %, as set forth in claims 3 and 18. As already stated concerning Issue 2, there exist an infinite number of combinations of alloy powders that could be combined to result in the overall

composition after melting set forth in claim 3 or claim 18, and there are an infinite number of these combinations in which at least one powder falls outside the range for the individual powders given in claims 3 and 18 of 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass %.

For this reason, modifying Kazem-Goudarzi as proposed by the Official Action does not automatically result in a solder paste having all the features of the solder pastes set forth in claim 3 and 18. There are no teachings in the references from which a person skilled in the art could select the specific ranges for the composition of the individual Sn alloy powders employed in claim 3 or claim 18. Additional teachings, not found in the references, are necessary before the references could be modified to have all the features recited in claims 3 and 18.

Accordingly, as there is no motivation to combine the cited references as proposed by the Official Action, and as the combined references would still not include all the features recited in the claims, the cited references cannot render any of claims 3 - 12, 14 - 16, 18 - 20, 23, and 24 obvious.

Dependent claims 4 - 7 are patentable for the reasons given above with respect to claim 3 and are separately patentable in their own right. As noted above, these claims describe specific combinations of Sn alloys for the two different Sn alloy powders set forth in claim 3. The three references cited in this rejection do not teach or suggest these combinations of alloy powders. In its preferred embodiment of a dual-alloy solder paste, Kazem-Goudarzi employs a tin-lead-silver alloy and a tin-lead-bismuth alloy (column 4, lines 3 - 8). None of the alloy combinations described in claims 4 - 7 are set forth. As has been described above, Seelig discloses only a tin-silver-copper-antimony alloy and thus teaches none of the alloys set forth in claims 4 - 7. Hitch teaches various ternary and higher solder alloys, among which are Sn-Ag-Cu alloys. However, Hitch is a single-alloy soldering

composition, not a dual-alloy soldering composition like Kazem-Goudarzi, and it teaches nothing about how to select the individual alloys of a dual-alloy soldering composition, so a person skilled in the art could not find any teaching in Hitch of two Sn alloy powders in a paste containing the same components as each other in different proportions as set forth in claim 4, of a plurality of metal powders in a solder paste including two different Sn-Ag-Cu alloy powders as set forth in claim 5, of the plurality of metal powders in a solder paste including a Sn-Ag alloy powder and a Sn-Cu alloy powder as set forth in claim 6, or of a plurality of metal powders in a solder paste including a Sn-Ag alloy powder, a Sn-Cu alloy powder, and a Sn-Ag-Cu alloy powder as set forth in claim 7.

Therefore, as the references do not contain teachings that could be combined to result in any of the specific combinations of solder alloy powders set forth in claims 4 - 7, the references cannot render these claims obvious. The rejections of claims 4 - 7 are thus improper and must be reversed.

Claims 9 and 10 are patentable for the reasons given above with respect to claim 3, and they are further patentable in their own right. Claim 9 describes a method of soldering using the solder paste of claim 3 at a reflow temperature of at most 250°C, and claim 10 describes a method of soldering using the solder paste of claim 3 at a reflow temperature of at most 240°C. The references contain no teachings that could be combined to result in a method having these features.

As set forth above, the method disclosed in Kazem-Goudarzi involves reflow soldering of a dual-alloy solder paste containing two different alloys (a low temperature alloy 115 and a high temperature alloy 120) to melt the alloys in two reflow steps. The highest reflow temperature must be higher than the melting range of the high temperature alloy 120 in order to melt both alloys. The reflow temperature used in Kazem-Goudarzi is thus determined by the melting temperatures of the individual alloys used in the dual-alloy solder

paste, not by the overall composition of the paste, so it is mandatory to first know what individual alloys are being employed as the dual alloys in order to select the reflow temperatures.

However, as discussed with respect to claim 3, none of the three cited references teaches alloys suitable for use as the individual alloys in the method of Kazem-Goudarzi so as to result in a lead-free Sn-Ag-Cu composition, since Seelig and Hitch both relate to a <u>single-alloy</u> solder paste and teach nothing about selecting the individual alloys of a dual-alloy solder paste. As there are no individual alloys which it would be obvious from the references to employ in the method of Kazem-Goudarzi to employ a lead-free Sn-Ag-Cu composition, the reflow temperatures, which are determined by the individual alloys, cannot be obvious. Claims 9 and 10 are therefore allowable.

In connection with claims 9 and 10, page 16 of the Official Action points out that the melting points of the alloys of Examples 1 - 3 of Hitch are 213 - 218°C, 214 - 215°C, and 214° - 216°C. The implication of the Official Action appears to be that these melting points would have some significance in determining the reflow temperature employed in the method of Kazem-Goudarzi, if modified as proposed by the Official Action. These melting points are in fact of no significance to a person skilled in the art in determining what reflow temperature to use in the method of Kazem-Goudarzi. Like Sakai in the previous rejection, Hitch is being relied upon in this rejection as teaching an <u>overall</u> composition for the dual-alloy solder paste of Kazem-Goudarzi, and as explained above, it is the melting points of the <u>individual</u> dual alloys, not the overall composition of the dual-alloy solder paste, which determines the reflow temperature in Kazem-Goudarzi. As pointed out with respect to claim 3, the alloys of Examples 1 - 3 of Hitch are unsuitable for use as the individual alloys in the method of Kazem-Goudarzi, so the melting points of these alloys of Hitch teach nothing about what reflow temperatures to be employed in Kazem-Goudarzi.

Each of dependent claims 20 and 24 is allowable for the reasons stated above with respect to claims 3 and 18, and each is further patentable in its own right. Dependent claims 20 and 24 each describe a method including completely melting the plurality of metals powders defined in claim 3 or claim 18, respectively, in a single reflow step. The cited references do not teach or suggest such a method.

The details of the melting process in the method disclosed by Kazem-Goudarzi have already been elaborated with respect to Issue 4, and as is clear from that discussion, the method of Kazem-Goudarzi separates the melting of different solder alloy particles into two separate steps. Namely, the only solder alloy particles which are melted in a first reflow step are particles of the low temperature alloy 115, and the only solder alloy particles which are melted during a second reflow step are particles of the high temperature alloy 120. Thus, Kazem-Goudarzi does not teach completely melting a plurality of different metal powders in a single reflow step, as in claims 20 and 24.

The Official Action proposes to modify the method disclosed in Kazem-Goudarzi such that the final composition of the solder obtained after melting particles of two different alloys would be a 93.8 - 96.4% Sn, 3.1 - 3.5% Ag, and 0.5 - 2.7% Cu composition taught by Hitch as one possible composition for a single-alloy solder. However, even if the method of Kazem-Goudarzi were so modified, the method of Kazem-Goudarzi would still entail melting particles of only one alloy in each of two reflow steps, no matter what specific alloys were employed as the two alloys. Thus, the resulting method would not include all the steps set forth in either claim 20 or 24. Accordingly, as the combined references would not include all the features of these claims, they cannot render these claims obvious. The rejections of claims 20 and 24 are therefore improper and must be reversed.

Summary

For the reasons given above, the grounds of rejection given in the Official Action for each of claims 1 - 24 are erroneous and should be reversed.

Respectfully submitted,

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APPENDIX

The claims being appealed are as follows:

1. A lead-free solder paste including a plurality of different types of metal powder mixed with a flux, one of the metal powders being a Sn alloy powder, another of the metal powders being selected from a Sn alloy powder, elemental Ag powder, elemental Cu powder, and elemental Sn powder,

each Sn alloy powder including 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn, the plurality of metal powders having a composition when melted of 1 - 5 mass % Ag, at least 0.5 and less than 3 mass % Cu, and a remainder of Sn.

2. A solder paste as claimed in claim 1 wherein one of the metal powders comprises an elemental metal powder of Ag, Cu or Sn.

3. A lead-free solder paste including a plurality of different types of metal powder mixed with a flux, the plurality of metal powders including two different Sn alloy powders, each Sn alloy powder including 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn, the plurality of metal powders having a composition when melted of 1 - 5 mass % Ag, 0.5 - 3 mass % Cu, and a remainder of Sn.

4. A solder paste as claimed in claim 3 wherein the two Sn alloy powders contain the same components as each other in different proportions.

5. A solder paste as claimed in claim 3 wherein the plurality of metal powders include two different Sn-Ag-Cu alloy powders.

6. A solder paste as claimed in claim 3 wherein one of the metal powders is a Sn-Ag alloy powder and another of the metal powders is a Sn-Cu alloy powder.

7. A solder paste as claimed in claim 3 wherein the plurality of metal powders include a Sn-Ag alloy powder, a Sn-Cu alloy powder, and a Sn-Ag-Cu alloy powder.

8. A method of soldering a surface mounted device comprising performing reflow soldering using the solder paste of claim 3.

9. A method as claimed in claim 8 including performing the reflow soldering at a reflow temperature of at most 250°C.

10. A method as claimed in claim 9 wherein the reflow temperature is at most 240°C.

11. A method as claimed in claim 8 wherein the surface mounted device comprises a chip component.

12. A method as claimed in claim 8 including printing the solder paste on a printed circuit board.

13. A solder paste as claimed in claim 1 wherein the plurality of metal powders have a composition when melted containing at most 1.0 mass % of Cu.

14. A solder paste as claimed in claim 3 wherein the plurality of metal powders have a composition when melted containing less than 3.0 mass % of Cu.

15. A solder paste as claimed in claim 3 wherein the plurality of metal powders have a composition when melted containing at most 1.0 mass % of Cu.

16. A method as claimed in claim 8 including melting the plurality of metal powders in the solder paste during the reflow soldering.

17. A method of soldering a surface mounted device comprising performing reflow soldering using the solder paste of claim 1, the reflow soldering including melting the plurality of metal powders in the solder paste.

18. A method of soldering comprising applying to a substrate a solder paste including a plurality of different types of metal powder mixed with a flux, one of the metal powders being a Sn alloy powder, another of the metal powders being selected from a Sn alloy powder, elemental Ag powder, elemental Cu powder, and elemental Sn powder, each Sn alloy powder including 0 - 8 mass % of Ag, 0 - 5 mass % of Cu, and at least 80 mass % of Sn, and heating the solder paste to melt the plurality of metal powders, the plurality of metal powders having a composition when melted of 1 - 5 mass % Ag, 0.5 - 3 mass % Cu, and a remainder of Sn.

19. A method as claimed in claim 16 including completely melting the plurality of metal powders in the reflow soldering.

20. A method as claimed in claim 19 including completely melting the plurality of metal powders in a single reflow step.

21. A method as claimed in claim 17 including completely melting the plurality of

metal powders in the reflow soldering.

22. A method as claimed in claim 21 including completely melting the plurality of metal powders in a single reflow step.

23. A method as claimed in claim 18 including heating the solder paste to completely melt the plurality of metal powders.

24. A method as claimed in claim 23 including completely melting the plurality of metal powders in a single reflow step.